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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		L9289.01162
		U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/890075
INTERNATIONAL APPLICATION NO. **PCT/JP00/08375**	INTERNATIONAL FILING DATE **November 28, 2000**	PRIORITY DATE CLAIMED **November 30, 1999**

TITLE OF INVENTION

CDMA RADIO RECEIVING APPARATUS AND CDMA RADIO RECEIVING METHOD

APPLICANT(S) FOR DO/EO/US

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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   - b. ☒ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☒ is attached hereto.
   - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☒ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☐ Other items or information:

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U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/890075	INTERNATIONAL APPLICATION NO. PCT/JP00/08375	ATTORNEY'S DOCKET NUMBER L9289.01162

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS	PTO USE ONLY
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$1000.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$860.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$710.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$690.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	**$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	12 - 20 =	0	x $18.00	**$0.00**	
Independent claims	10 - 3 =	7	x $80.00	**$560.00**	
Multiple Dependent Claims **(check if applicable).**			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,420.00**	
☐ Applicant claims small entity status. (See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				**$0.00**	
SUBTOTAL =				**$1,420.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$1,420.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☒	**$40.00**	
TOTAL FEES ENCLOSED =				**$1,460.00**	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of **$1,460.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ______________ in the amount of ______________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **19-4375** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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6/PRTS

DESCRIPTION

CDMA RADIO RECEIVING APPARATUS AND CDMA RADIO RECEIVING METHOD

Technical Field

The present invention relates to a CDMA radio receiving apparatus and a CDMA radio receiving method.

Background Art

Recently, the demand for terrestrial mobile communications such as mobile phones has been growing remarkably, and technologies for efficient frequency use in order to secure a larger number of subscribers in a limited frequency band have become important.

The CDMA method is attracting attention as one multiple access method for using frequencies efficiently. CDMA is a multiple access method using spread spectrum communication technology that offers expectations of diversity effectiveness through being resistant to the influence of multipath distortion and by maximal-ratio combining of multipath components.

A CDMA radio receiving apparatus used in this CDMA method finds the phase rotation speed per symbol from a phase rotation amount on the orthogonal coordinate plane of a known signal within a received signal, and performs Auto Frequency Control (AFC) according to that phase rotation speed. By performing this AFC, a CDMA radio

receiving apparatus compensates for variation of the received signal carrier frequency that occurs due to precision error of the frequency oscillator between itself and the transmitting side.

A conventional CDMA radio receiving apparatus will now be described using FIG. 1. FIG. 1 is a principal block diagram showing the outline configuration of a conventional CDMA radio receiving apparatus. In the following description, the transmitting side is described as a base station and the receiving side as a mobile station.

In FIG. 1, a radio receiving section 12 amplifies a radio signal including a known signal received via an antenna 11, multiplies together that amplified received signal and a carrier, and extracts a baseband signal from the received signal. In the following description, the processing for extracting a baseband signal from a received signal is called "quasi-coherent detection processing."

A despreading section 13 performs despreading processing by multiplying together the baseband signal and a spreading code. A coherent detection and demodulation section 14 performs predetermined detection processing on the signal subjected to despreading processing, and obtains receive data.

A control section 15 calculates the phase angle--that is, the phase rotation amount--on the orthogonal coordinate plane of the known signal subjected

to despreading processing, and from that phase rotation amount detects the phase change amount per symbol--that is, the phase rotation speed of the known signal. The control section 15 then controls a Voltage Controlled Oscillator (VCO) 16 according to the phase rotation speed.

The VCO 16 is an oscillator that generates a carrier used in quasi-coherent detection processing in the radio receiving section 12, and varies the carrier frequency through control by the control section 15.

In this way, a conventional CDMA radio receiving apparatus detects the phase rotation speed using a received known signal, and performs AFC by varying the oscillation frequency of the VCO according to this phase rotation speed. By this means, a conventional CDMA radio receiving apparatus compensates for drift between the carrier frequency of a received signal, and the frequency of the carrier generated by the VCO.

A CDMA radio receiving apparatus cannot perform coherent detection and demodulation until phase rotation occurring in the baseband signal has converged.

However, there is a problem with a conventional CDMA radio receiving apparatus, as follows.

Namely, with a conventional CDMA radio receiving apparatus, in order to increase the reliability of the phase rotation speed value, the current phase rotation speed is calculated by finding the moving average of phase rotation speeds calculated in the past, for example. When this is done, the longer the interval used in

calculating the moving average, the higher is the reliability of the moving average value, but the longer the interval, the longer is the time required before the frequency error between the transmitting frequency oscillator and the receiving frequency oscillator is canceled. As a result, a long time is required for phase rotation occurring in the baseband signal to converge, and during this time the CDMA radio receiving apparatus cannot perform coherent detection and demodulation of a received signal.

On the other hand, if a short interval is used, the reliability of the moving average value is low, and it is possible that phase rotation occurring in the baseband signal will not converge, or that even if it does converge it will be unstable and become diffuse again. As a result, the CDMA radio receiving apparatus cannot perform stable coherent detection and demodulation on a received signal.

Thus, while reliability increases as the length of the interval for calculating the moving average increases, the time during which the CDMA radio receiving apparatus cannot perform coherent detection and demodulation on a received signal increases; and on the other hand, if the interval used for calculating the moving average is shortened, reliability falls and the CDMA radio receiving apparatus cannot perform stable coherent detection and demodulation on a received signal. It is therefore necessary to set the shortest interval that enables reliability of the moving average to be ensured. However,

there is a problem in that it is difficult to set a suitable interval (suitable parameter) for different CDMA radio receiving apparatuses.

There is also a method whereby, when a mobile station is powered on, for example, phase rotation occurring in the baseband signal is converged to some extent by calculating a moving average using a short interval, after which phase rotation occurring in the baseband signal continues to be converged by calculating the moving average using a long interval, and improving the reliability of the moving average value. The problem in this case, however, is that it is difficult to set a suitable timing for switching from a short interval to a long interval for different CDMA radio receiving apparatuses, and so switching control is difficult.

Also, with the TDD (Time Division Duplex) method, the downlink from a base station to a mobile station and the uplink from a mobile station to a base station are multiplexed by time division, so that a long time is required before the mobile station receives the number of pilot symbol samples necessary to obtain a highly reliable phase rotation speed value by means of a moving average. As a result, there is a problem in that a long time is required for phase rotation occurring in the baseband signal to converge, and during this time a CDMA radio receiving apparatus cannot perform coherent detection and demodulation on received signals.

Disclosure of Invention

It is an objective of the present invention to provide a CDMA radio receiving apparatus and CDMA radio receiving method in which parameter setting is easy, and control for converging phase rotation occurring in a baseband signal is also simple.

The inventors of the present invention focused on the fact that, as long as a received signal continues to undergo sequential phase rotation of an amount virtually constant over time, a phase of a received signal goes on rotating by a constant amount with time,

the known signal part within a received signal will also continue to undergo sequential phase rotation per chip within one symbol, and found that the state of phase rotation can be ascertained from the correlation between the known signal part within a received signal and the known signal spread with a sequentially rotated spreading code, to arrive at the present invention.

In order to achieve the above-described objective, in the present invention the correlation is calculated between the known signal part in a received signal and the signal (called "replica signal" below) resulting from spreading the known signal with a spreading code (called "replica code" below) sequentially rotated in the same series as the spreading code that spread the known signal in the received signal and sequentially rotated by a predetermined phase rotation amount, and whether or not the size of the phase rotation is within the permissible

range is judged from the size of that correlation value.

Brief Description of Drawings

FIG.1 is a principal block diagram showing the outline configuration of a conventional CDMA radio receiving apparatus;

FIG.2 is a principal block diagram showing the outline configuration of a CDMA radio receiving apparatus according to Embodiment 1 of the present invention;

FIG.3 is a drawing showing the phase rotation of a replica code used by a CDMA radio receiving apparatus according to Embodiment 1 of the present invention;

FIG.4 is a principal block diagram showing the outline configuration of a CDMA radio receiving apparatus according to Embodiment 2 of the present invention;

FIG.5 is a drawing showing variation of the phase rotation amount of a replica code used by a CDMA radio receiving apparatus according to Embodiment 2 of the present invention; and

FIG.6 is a principal block diagram showing the outline configuration of a CDMA radio receiving apparatus according to Embodiment 3 of the present invention.

Best Mode for Carrying out the Invention

Embodiments of the present invention will be described specifically below with reference to accompanying drawings.

(Embodiment 1)

A CDMA radio receiving apparatus according to Embodiment 1 of the present invention calculates a correlation value, giving only a predetermined phase rotation amount Ä per chip as a parameter for a replica code, and detects the state of phase rotation according to the size of that correlation value.

A CDMA radio receiving apparatus according to Embodiment 1 of the present invention will be described below using FIG.2. FIG.2 is a principal block diagram showing the outline configuration of a CDMA radio receiving apparatus according to Embodiment 1 of the present invention.

In FIG.2, a radio receiving section 102 amplifies a radio signal including a known signal received via an antenna 101, and a baseband signal is extracted from that amplified received signal by multiplying it by a carrier.

A despreading section 103 performs despreading processing by multiplying together the data part in the baseband signal and a spreading code. A coherent detection and demodulation section 104 performs predetermined demodulation processing on the signal that has undergone despreading processing, and receive data is obtained.

A first correlation value calculation section 105-1 to third correlation value calculation section 105-3 calculate correlation values between the known signal part in the baseband signal and replica signals generated

by a first replica signal generation section 106-1 to third replica signal generation section 106-3, respectively.

A comparison section 107 detects the phase rotation state of a known reference signal by comparing the correlation values calculated by the first correlation value calculation section 105-1 to third correlation value calculation section 105-3, respectively, and selecting the largest correlation value. Here, "phase rotation state" means the direction of phase rotation and degree of phase rotation (whether or not the size of phase rotation is within the permissible range).

A control section 108 generates a control voltage to a VCO 109 according to the detected phase rotation state. The control section 108 reduces the control voltage by a predetermined amount to lower the frequency of the carrier generated by the VCO 109 if the direction of phase rotation is "positive" and the size of phase rotation is outside the permissible range, and increases the control voltage by a predetermined amount to raise the frequency of the carrier generated by the VCO 109 if the direction of phase rotation is "negative" and the size of phase rotation is outside the permissible range. This control is based on the fact that the direction of phase rotation is "positive" when the frequency of the carrier generated by the VCO 109 is high relative to the carrier frequency of the received signal, and "negative" when the frequency of the carrier generated by the VCO

109 is low relative to the carrier frequency of the received signal.

The control voltage control method is not limited to this. For example, an apparatus configuration can also be used whereby the control section 108 lowers the carrier frequency by increasing the control voltage by a predetermined amount, and raises the carrier frequency by reducing the control voltage by a predetermined amount.

The VCO 109 is an oscillator that generates a carrier used in quasi-coherent detection processing in the radio receiving section 102. The VCO 109 varies the frequency of the carrier in proportion to the control voltage generated by the control section 108, bringing the frequency of the carrier close to the carrier frequency of the received signal. By this means, phase rotation occurring in the baseband signal is gradually converged.

The carrier frequency control method is not limited to this. For example, an apparatus configuration can also be used whereby the VCO 109 varies the frequency of the carrier in inverse proportion to the control voltage generated by the control section 108.

Next, the operation of a CDMA radio receiving apparatus having the above-described configuration will be described using FIG.3. FIG.3 is a drawing showing phase rotation of a replica code used by a CDMA radio receiving apparatus according to Embodiment 1 of the present invention.

Of the baseband signal extracted by the radio

receiving section 102, the known signal part is output to first correlation value calculation section 105-1 to third correlation value calculation section 105-3.

As long as a received signal continues to undergo sequential phase rotation of an amount virtually constant over time, the known signal part within the received signal will also continue to undergo sequential phase rotation per chip within one symbol. Therefore, the first replica signal generation section 106-1 generates a first replica signal whereby a known signal is spread with a first replica code that rotates by a first angle of rotation +Ä at a time for each chip, as shown in FIG.3. Also, the third replica signal generation section 106-3 generates a third replica signal whereby a known signal is spread with a third replica code that rotates by a third angle of rotation -Ä at a time for each chip, as shown in FIG.3. And the second replica signal generation section 106-2 generates a second replica signal whereby a known signal is spread with a second replica code that does not rotate, as shown in FIG.3. The first angle of rotation +Ä and the third angle of rotation -Ä are predetermined angles of rotation, and their sizes are equal.

Next, the first correlation value calculation section 105-1 to third correlation value calculation section 105-3 calculate respectively the correlation values between the known signal part in the received signal and the replica signal. That is to say, the first correlation value calculation section 105-1 calculates

the correlation between the first replica signal rotating by +Ä at a time for each chip and the known signal part in the received signal, the second correlation value calculation section 105-2 calculates the correlation between the second replica signal that does not rotate and the known signal part in the received signal, and the third correlation value calculation section 105-3 calculates the correlation between the third replica signal rotating by -Ä at a time for each chip and the known signal part in the received signal.

Normally, when phase rotation occurs, the known signal part in the received signal goes on rotating by a fixed rotation amount over time in one direction, "positive" or "negative." That is to say, the known signal part in the received signal goes on rotating by a fixed rotation amount for each chip in either the positive or negative direction. Therefore, if the known signal part in the received signal rotates greatly in the "positive" direction and the size of phase rotation is outside the permissible range, of the three correlation values calculated by correlation value calculation sections 105-1 to 105-3, the correlation value calculated by the first correlation value calculation section 105-1 will be the largest, and if the known signal part in the received signal rotates greatly in the "negative" direction and the size of phase rotation is outside the permissible range, of the three correlation values calculated by correlation value calculation sections

105-1 to 105-3, the correlation value calculated by the third correlation value calculation section 105-3 will be the largest. If the size of phase rotation of the known signal part in the received signal is within the permissible range, of the three correlation values calculated by correlation value calculation sections 105-1 to 105-3, the correlation value calculated by the second correlation value calculation section 105-2 will be the largest.

Here, a case where the size of phase rotation is within the permissible range means a case where the correlation value calculated by the second correlation value calculation section 105-2 is equal to or greater than the correlation value calculated by the first correlation value calculation section 105-1 and the correlation value calculated by the third correlation value calculation section 105-3, and a case where the size of phase rotation is outside the permissible range means a case where the correlation value calculated by the first correlation value calculation section 105-1 or the correlation value calculated by the third correlation value calculation section 105-3 is greater than the correlation value calculated by the second correlation value calculation section 105-2.

Thus, the comparison section 107 detects the phase rotation state of the known signal part in the received signal by comparing the three correlation values calculated by the correlation value calculation sections

105-1 to 105-3, and selecting the largest correlation value. To be specific, if the correlation value calculated by the third correlation value calculation section 105-3 is the largest of the three correlation values calculated by the correlation value calculation sections 105-1 to 105-3, the comparison section 107 detects that the size of phase rotation is outside the permissible range and the direction of rotation is "positive," and if the correlation value calculated by the third correlation value calculation section 105-3 is the largest of the three correlation values calculated by the correlation value calculation sections 105-1 to 105-3, the comparison section 107 detects that the size of phase rotation is outside the permissible range and the direction of rotation is "negative." And if the correlation value calculated by the second correlation value calculation section 105-2 is the largest of the three correlation values calculated by the correlation value calculation sections 105-1 to 105-3, the comparison section 107 detects that phase rotation of the known signal part in the received signal is within the permissible range. The comparison section 107 then outputs to the control section 108 a control signal indicating the phase rotation state of the known signal part in the received signal.

In accordance with this control signal, if the size of phase rotation is outside the permissible range and its direction of rotation is "positive," the control

section 108 reduces the control voltage by a predetermined amount to lower the frequency of the carrier generated by the VCO 109, and if the size of phase rotation is outside the permissible range and its direction of rotation is "negative," the control section 108 increases the control voltage by a predetermined amount to raise the frequency of the carrier generated by the VCO 109. And if a control signal indicating that the size of the phase rotation is within the permissible range is output, the control section 108 holds the control voltage constant to maintain the frequency of the carrier generated by the VCO 109.

Next, the operation of the above-described CDMA radio receiving apparatus will be described in concrete terms using equations.

If the spreading code that spreads the known signal part in the received signal is designated

$$\boldsymbol{C}=\begin{pmatrix} C_{ik} \\ C_{qk} \end{pmatrix} \qquad \cdots (1)$$

the above-described three kinds of replica signal R can be expressed by equation (2) below.

$$\boldsymbol{R}=\begin{pmatrix} \mathrm{R}_{\mathrm{ik}} \\ \mathrm{R}_{\mathrm{qk}} \end{pmatrix}=\begin{pmatrix} \cos\psi & \sin\psi \\ -\sin\psi & \cos\psi \end{pmatrix}\begin{pmatrix} \mathrm{C}_{\mathrm{ik}} \\ \mathrm{C}_{\mathrm{qk}} \end{pmatrix} \qquad \text{where } \psi=\alpha+(k-1)\theta \qquad \cdots (2)$$

Here, i indicates the in-phase component, q the quadrature phase component, k the number of chips (k = 1 to K), and á a constant (rotation amount when k = 1). It is then possible to express the above three kinds of replica code by making è +Ä with the first replica code,

-Ä with the third replica code, and 0 with the second replica code.

Also, the known signal part S in a received signal can be expressed by equation (3) below.

$$S=\begin{pmatrix} S_{ik} \\ S_{qk} \end{pmatrix}=\begin{pmatrix} \cos\sigma & \sin\sigma \\ -\sin\sigma & \cos\sigma \end{pmatrix}\begin{pmatrix} C_{ik} \\ C_{qk} \end{pmatrix} \quad \text{where } \sigma=\beta+(k-1)\gamma \qquad \cdots (3)$$

Here, i indicates the in-phase component, q the quadrature phase component, k the number of chips (k = 1 to K), â a constant (rotation amount of the known reference signal when k = 1), and γ the rotation amount per chip of the received signal.

The first correlation value calculation section 105-1 to third correlation value calculation section 105-3 respectively perform calculation of the correlation between the replica signal indicated by above equation (2) and the known signal part in the received signal indicated by above equation (3).

For example, if the radio frequency band is 2 [GHz], and the carrier frequency error is 1 [ppm], the known signal part in the received signal will rotate 2ð [rad] in 0.5 [ms]. Therefore, if one slot is 0.625 [ms] and the number of chips is 2560 [chips], then if the number of chips of the despreading code despreading the known signal part in the received signal is 512 [chips], the known signal part in the received signal will rotate (1/2)ð [rad] in 512 [chips]--that is, 0.125 [ms].

Here, if |Ä| = |γ| and the direction of rotation

is "positive," and if a first replica code +Ä setting and third replica code -Ä setting are made, as the results of the correlation value calculations made with above equation (2) and above equation (3), the first correlation value calculation section 105-1 calculates "512" as the correlation value, the second correlation value calculation section 105-2 calculates "461" (rounding the decimal part to the nearest whole number) as the correlation value, and the third correlation value calculation section 105-3 calculates "325" (rounding the decimal part to the nearest whole number) as the correlation value.

These correlation values are the values calculated by performing simulation by substituting the respective values in above equations (2) and (3). To simplify the present simulation, it is assumed that á = â = 0.

The comparison section 107 compares the correlation values, and since the size relationship of the correlation values is "512 > 461 > 325," detects that the size of the phase rotation of the known signal part in the received signal is outside the permissible range, and that its direction is "positive." The comparison section 107 then outputs a control signal indicating the phase rotation state to the control section 108.

In this embodiment, the configuration is such that the comparison section 107 outputs a control signal indicating the phase rotation state of the known signal part in the received signal to the control section 108,

and the control section 108 adjusts the carrier frequency generated by the VCO 109 by a predetermined amount according to this control signal. However, a configuration can also be used whereby the comparison section 107 outputs correlation values to the control section 108 together with a control signal indicating the phase rotation state of the known signal part in the received signal, and the control section 108 adaptively varies the amount of adjustment of the carrier frequency generated by the VCO 109 according to the size of each correlation value.

In the above description, the configuration is such that the first correlation value calculation section 105-1 to third correlation value calculation section 105-3 calculate the correlation between the known signal part in the received signal and the replica signals generated by the first replica signal generation section 106-1 to third replica signal generation section 106-3, respectively.

However, in CDMA communication, there is a method whereby slot timing detection, etc., is performed by transmitting, on the transmitting side, a signal that has a midamble part created by a known code, and, on the receiving side, performing calculation of the correlation between a received signal including the known code and the known code.

In CDMA communication using this kind of method, a configuration can be used whereby the first correlation

value calculation section 105-1 to third correlation value calculation section 105-3 calculate the correlation between a known code of a midamble part in the received signal and replica codes generated by the first replica signal generation section 106-1 to third replica signal generation section 106-3, respectively. In this case, the replica codes are codes that are sequentially rotated in the same series as the known code of the midamble part and by a predetermined phase rotation amount.

Thus, according to a CDMA radio receiving apparatus according to this embodiment, correlation values are calculated, giving only a predetermined phase rotation amount Ä for each chip as a parameter corresponding to a replica code, and the phase rotation state is detected according to the size of those correlation values, so that parameter setting is easy and control for converging the phase rotation amount occurring in the baseband signal is also simple.

(Embodiment 2)

A CDMA radio receiving apparatus according to Embodiment 2 of the present invention differs from Embodiment 1 in that, when the size of phase rotation is within the permissible range, the phase rotation range is reduced by decreasing the replica code angle of phase rotation Ä for each chip.

A CDMA radio receiving apparatus according to Embodiment 2 of the present invention will be described

below using FIG.4. FIG.4 is a principal block diagram showing the outline configuration of a CDMA radio receiving apparatus according to Embodiment 2 of the present invention. The parts in FIG.4 identical to those in FIG.2 are assigned the same numbers as in FIG.2, and their detailed explanations are omitted.

In FIG.4, a comparison section 107 outputs a control signal indicating the phase rotation state of a known signal part in a received signal to a control section 108 and an angle of rotation control section 301.

When a control signal indicating that the size of phase rotation of the known signal part in the received signal is within the permissible range is output from the comparison section 107, the angle of rotation control section 301 performs control that decreases the variation amount of the first angle of rotation +Ä and third angle of rotation -Ä.

Next, the operation of a CDMA radio receiving apparatus having the above-described configuration will be described using FIG.5. FIG.5 is a drawing showing variation of the phase rotation amount of a replica code used by a CDMA radio receiving apparatus according to Embodiment 2 of the present invention.

If the size of phase rotation of the known signal part in the received signal is within the permissible range, of the three correlation values calculated by correlation value calculation sections 105-1 to 105-3, the correlation value calculated by the second

correlation value calculation section 105-2 will be the largest. Thus, if a control signal indicating that the size of phase rotation of the known signal part in the received signal is within the permissible range is output from the comparison section 107, the angle of rotation control section 301 performs control of the first replica signal generation section 106-1 to decrease the variation amount of the first angle of rotation +Ä, and performs control of the third replica signal generation section 106-3 to decrease the variation amount of the third angle of rotation -Ä.

As shown in FIG.5, through this angle of rotation control? (control of rotation angle?), the first angle of rotation changes from +Ä1 to +Ä2, and the third angle of rotation changes from -Ä1 to -Ä2, the variation amount of each angle of rotation decreasing equally. Therefore, when the size of phase rotation of the known signal part in the received signal is within the permissible range, the phase rotation range is gradually reduced, so that it becomes possible to converge baseband signal phase rotation quickly and with high precision.

In accordance with this control, the first replica signal generation section 106-1 generates a first replica signal for which the amount of variation of the angle of rotation has been reduced, and the third replica signal generation section 106-3 generates a third replica signal for which the amount of variation of the angle of rotation has been reduced. The first correlation value

calculation section 105-1 and third correlation value calculation section 105-3 then calculate the correlation between the replica signals for which the amount of variation of the angle of rotation has been reduced and the known signal part in the received signal.

Thus, according to a CDMA radio receiving apparatus according to this embodiment, when the size of phase rotation is within the permissible range, the phase rotation range is reduced by decreasing the replica code angle of phase rotation Ä for each chip, so that when the size of phase rotation is within the permissible range, it is possible to converge baseband signal phase rotation quickly and with high precision without the necessity of switching control, etc., for which setting of the timing for switching the moving average calculation interval has heretofore been difficult.

(Embodiment 3)

A CDMA radio receiving apparatus according to Embodiment 3 of the present invention differs from Embodiment 1 in that finger assignment is performed according to a delay profile created by means of a replica code to which phase rotation is added.

A CDMA radio receiving apparatus according to Embodiment 3 of the present invention will be described below using FIG.6. FIG.6 is a principal block diagram showing the outline configuration of a CDMA radio receiving apparatus according to Embodiment 3 of the

present invention. The parts in FIG.6 identical to those in FIG.2 are assigned the same numbers as in FIG.2, and their detailed explanations are omitted.

A first delay profile creation section 501-1 to third delay profile creation section 501-3 create delay profiles from the correlation values calculated by the first correlation value calculation section 105-1 to third correlation value calculation section 105-3, respectively. Therefore, each delay profile is a delay profile of a state for which phase rotation has been added. After outputting correlation values used in AFC control, the first correlation value calculation section 105-1 to third correlation value calculation section 105-3 continue to perform correlation value calculation in order to create delay profiles chip by chip.

A selection section 502 selects the delay profile created from the largest correlation value, according to a control signal output from the comparison section 107. A finger assignment section 503 performs finger assignment to the despreading section 103 in accordance with the delay profile selected by the selection section 502.

Next, the operation of a CDMA radio receiving apparatus having the above-described configuration will be described.

The comparison section 107 outputs a control signal indicating the phase rotation state of a known reference signal to the control section 108 and selection section

502. Also, a first delay profile to third delay profile created by the first delay profile creation section 501-1 to third delay profile creation section 501-3 are output to the selection section 502.

In accordance with a control signal output from the comparison section 107, the selection section 502 selects the delay profile created from the largest correlation value of the three correlation values calculated by the correlation value calculation sections 105-1 to 105-3, and outputs it to the finger assignment section 503.

To be specific, if the comparison section 107 outputs a control signal indicating that the size of phase rotation of the known signal part in the received signal is outside the permissible range and its direction is "positive," the selection section 502 selects the first delay profile. Similarly, if the comparison section 107 outputs a control signal indicating that the size of phase rotation of the known signal part in the received signal is outside the permissible range and its direction is "negative," the selection section 502 selects the third delay profile; and if the comparison section 107 outputs a control signal indicating that the size of phase rotation of the known signal part in the received signal is within the permissible range, the selection section 502 selects the second delay profile. By this means, a delay profile created by means of a spreading code with phase rotation added or a known code with phase rotation added is selected according to the phase rotation state.

Next, the finger assignment section 503 outputs to the despreading section 103 a signal indicating the position of each finger on the delay profile selected by the selection section 502. The despreading section 103 then performs despreading processing on the received signal in accordance with the timing at which each finger is raised.

Thus, according to a CDMA radio receiving apparatus according to this embodiment, since finger assignment is performed according to a delay profile created from a replica code with phase rotation added, precise finger assignment is possible even if phase rotation occurs in the baseband signal. It is therefore possible to estimate accurately the reception timing of a delayed wave.

A CDMA radio receiving apparatus according to above-described Embodiments 1 to 3 can be applied to a communication terminal apparatus or base station apparatus in a radio communication system.

Also, above-described Embodiments 1 to 3 can be implemented in combination as appropriate.

According to the present invention, as described above, parameter settings can be made easily, and control for converging phase rotation occurring in a baseband signal can also be performed simply.

This application is based on the Japanese Patent Application No.HEI 11-340121 filed on November 30, 1999, entire content of which is expressly incorporated by reference herein.

CLAIMS

1. A CDMA radio receiving apparatus comprising:

a generator for generating a replica signal by spreading a known signal with a spreading code while sequentially rotating a phase of the spreading code by a predetermined phase rotation amount, the spreading code being the same series as a spreading code with which a known signal part in a received signal is spread

a calculator for calculating a correlation value between said known signal part and said replica signal;

a detector for detecting the phase rotation state from calculated correlation values; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

2. A CDMA radio receiving apparatus comprising:

a generator for generating a replica code, in the same series as a known code included in a received signal and sequentially rotated by a predetermined phase rotation amount;

a calculator for calculating a correlation value between said known code and said replica code;

a detector for detecting the phase rotation state from calculated correlation values; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

3. The CDMA radio receiving apparatus according to claim 1, wherein said generator decreases a predetermined phase rotation amount by a predetermined amount when the size of detected phase rotation is within a permissible range.

4. The CDMA radio receiving apparatus according to claim 1, further comprising:

a creator for creating a delay profile to which phase rotation is added from a calculated correlation value; and

a despreader for performing despreading on a received signal according to said delay profile.

5. A CDMA radio receiving apparatus comprising:

a first calculator for calculating a first correlation value between a first replica signal that spreads a known signal, in the same series as a spreading code that spreads a known signal part in a received signal and with a spreading code sequentially rotated by a predetermined phase rotation amount, and said known signal;

a second calculator for calculating a second correlation value between a second replica signal that spreads a known signal with a spreading code that spreads said known signal part, and said known signal part;

a comparator-detector for detecting phase rotation state by comparing said first correlation value and said

second correlation value; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

6. A CDMA radio receiving apparatus comprising:

a first calculator for calculating a first correlation value between a replica code in the same series as a known code included in a received signal and sequentially rotated by a predetermined phase rotation amount, and said known code included in said received signal;

a second calculator for calculating a second correlation value between a known code and said known code included in said received signal;

a comparator-detector for detecting phase rotation state by comparing said first correlation value and said second correlation value; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

7. A communication terminal apparatus incorporating a CDMA radio receiving apparatus, said CDMA radio receiving apparatus comprising:

a generator for generating a replica signal that spreads a known signal, in the same series as a spreading code that spreads a known signal part in a received signal

and with a spreading code sequentially rotated by a predetermined phase rotation amount;

a calculator for calculating a correlation value between said known signal part and said replica signal;

a detector for detecting the phase rotation state from calculated correlation values; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

8. A communication terminal apparatus incorporating a CDMA radio receiving apparatus, said CDMA radio receiving apparatus comprising:

a generator for generating a replica code, in the same series as a known code included in a received signal and sequentially rotated by a predetermined phase rotation amount;

a calculator for calculating a correlation value between said known code and said replica code;

a detector for detecting the phase rotation state from calculated correlation values; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

9. A base station apparatus incorporating a CDMA radio receiving apparatus, said CDMA radio receiving apparatus comprising:

a generator for generating a replica signal that spreads a known signal, in the same series as a spreading code that spreads a known signal part in a received signal and with a spreading code sequentially rotated by a predetermined phase rotation amount;

a calculator for calculating a correlation value between said known signal part and said replica signal;

a detector for detecting the phase rotation state from calculated correlation values; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

10. A base station apparatus incorporating a CDMA radio receiving apparatus, said CDMA radio receiving apparatus comprising:

a generator for generating a replica code, in the same series as a known code included in a received signal and sequentially rotated by a predetermined phase rotation amount;

a calculator for calculating a correlation value between said known code and said replica code;

a detector for detecting the phase rotation state from calculated correlation values; and

a carrier generator for generating a carrier by varying the frequency when the size of detected phase rotation is outside a permissible range.

11. A CDMA radio receiving method for detecting the phase rotation state by calculating a correlation value between a replica signal that spreads a known signal, in the same series as a spreading code that spreads a known signal part in a received signal and with a spreading code sequentially rotated by a predetermined phase rotation amount, and said known signal part; and varying the frequency of a carrier when the size of detected phase rotation is outside a permissible range.

12. A CDMA radio receiving method for detecting the phase rotation state by calculating a correlation value between a replica code in the same series as a known code included in a received signal and sequentially rotated by a predetermined phase rotation amount, and said known code; and varying the frequency of a carrier when the size of detected phase rotation is outside a permissible range.

ABSTRACT

A first correlation value calculation section 105-1 calculates a first correlation value between a first replica signal sequentially rotated by a predetermined rotation amount in a positive direction and a known signal part in a received signal, a second correlation value calculation section 105-2 calculates a second correlation between a second replica signal that is not rotated and a known signal part in a received signal, a third correlation value calculation section 105-3 calculates a third correlation between a third replica signal sequentially rotated by a predetermined rotation amount in a negative direction and a known signal part in a received signal, a comparison section 107 detects the phase rotation direction by selecting the largest correlation value of the first correlation value to third correlation value, a control section 108 varies a control voltage according to the phase rotation direction, and a VCO 109 generates a carrier of a frequency that is in accordance with the control voltage.

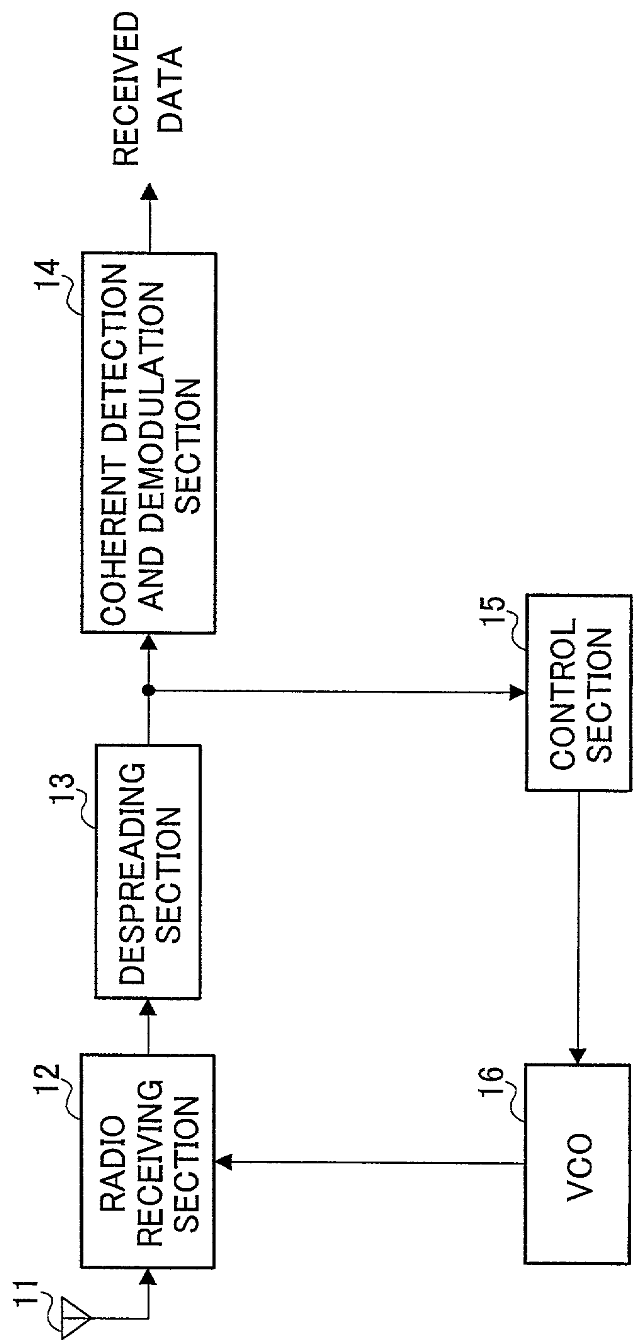
RECEIVED DATA
14
COHERENT DETECTION AND DEMODULATION SECTION
13
DESPREADING SECTION
12
RADIO RECEIVING SECTION
11
15
CONTROL SECTION
16
VCO

FIG.1

09/890075

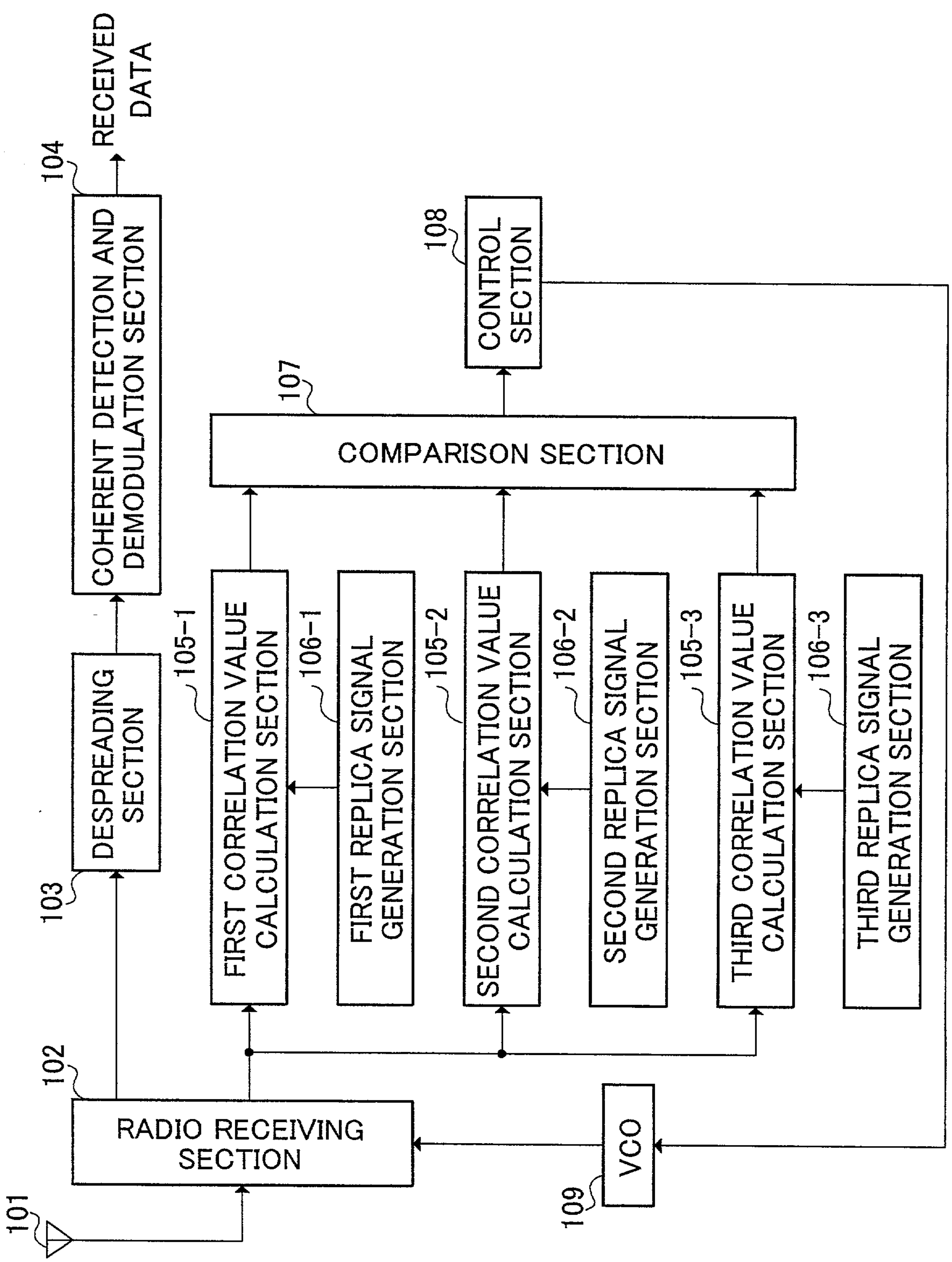

FIG.2

09/890075

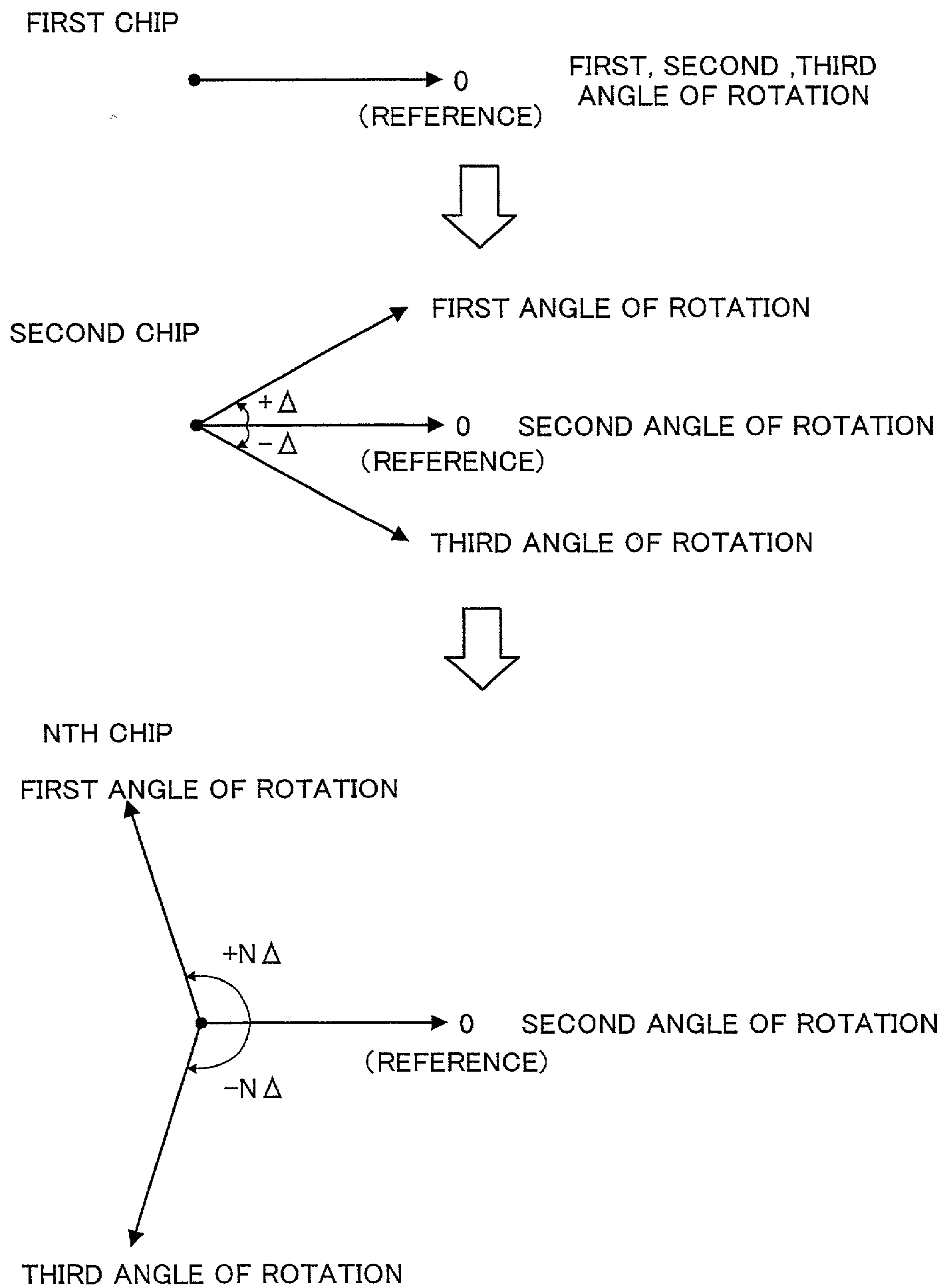

FIG.3

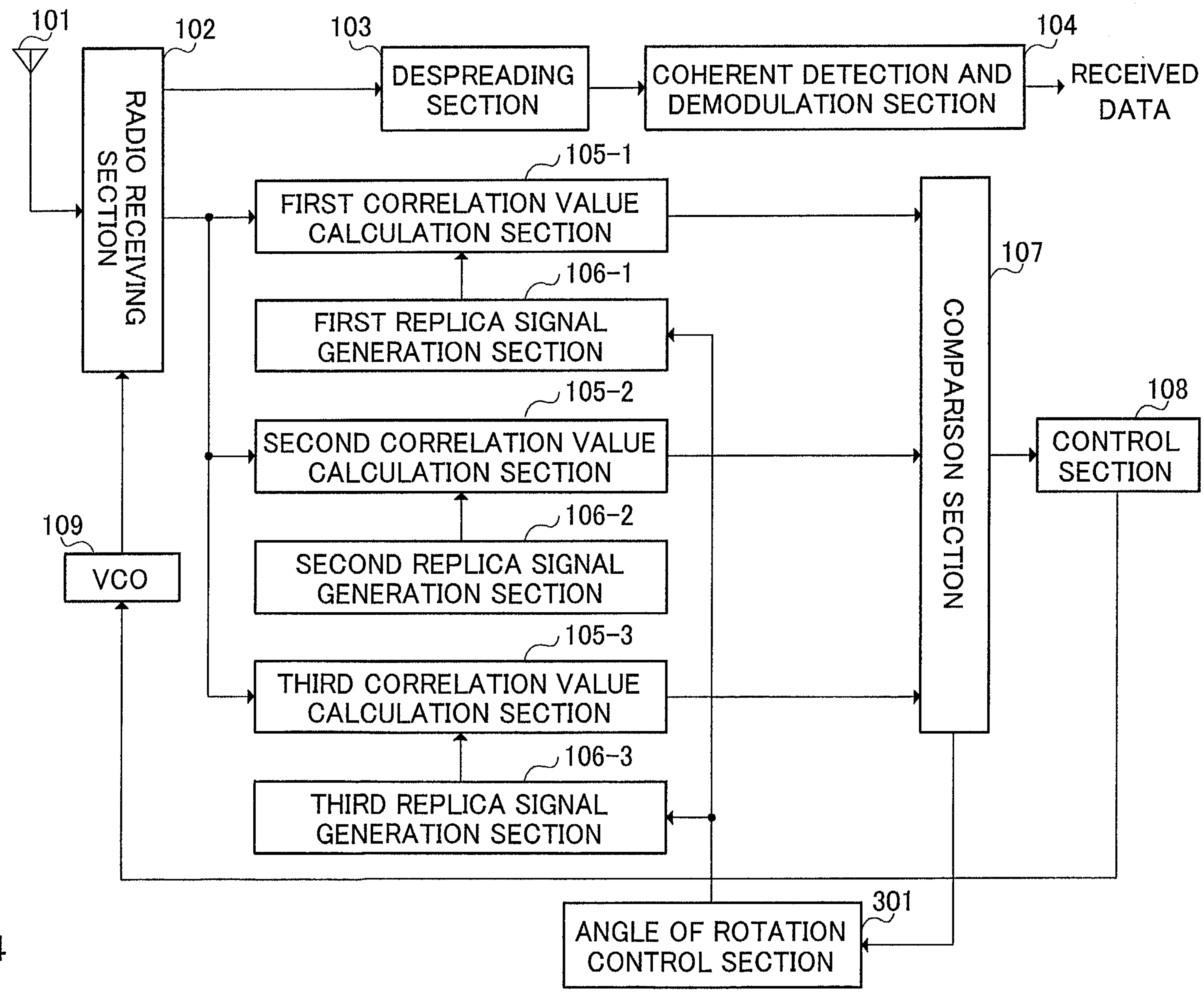
101
102
RADIO RECEIVING SECTION
103
DESPREADING SECTION
104
COHERENT DETECTION AND DEMODULATION SECTION
RECEIVED DATA
105-1
FIRST CORRELATION VALUE CALCULATION SECTION
106-1
FIRST REPLICA SIGNAL GENERATION SECTION
105-2
SECOND CORRELATION VALUE CALCULATION SECTION
106-2
SECOND REPLICA SIGNAL GENERATION SECTION
105-3
THIRD CORRELATION VALUE CALCULATION SECTION
106-3
THIRD REPLICA SIGNAL GENERATION SECTION
107
COMPARISON SECTION
108
CONTROL SECTION
109
VCO
301
ANGLE OF ROTATION CONTROL SECTION

FIG.4

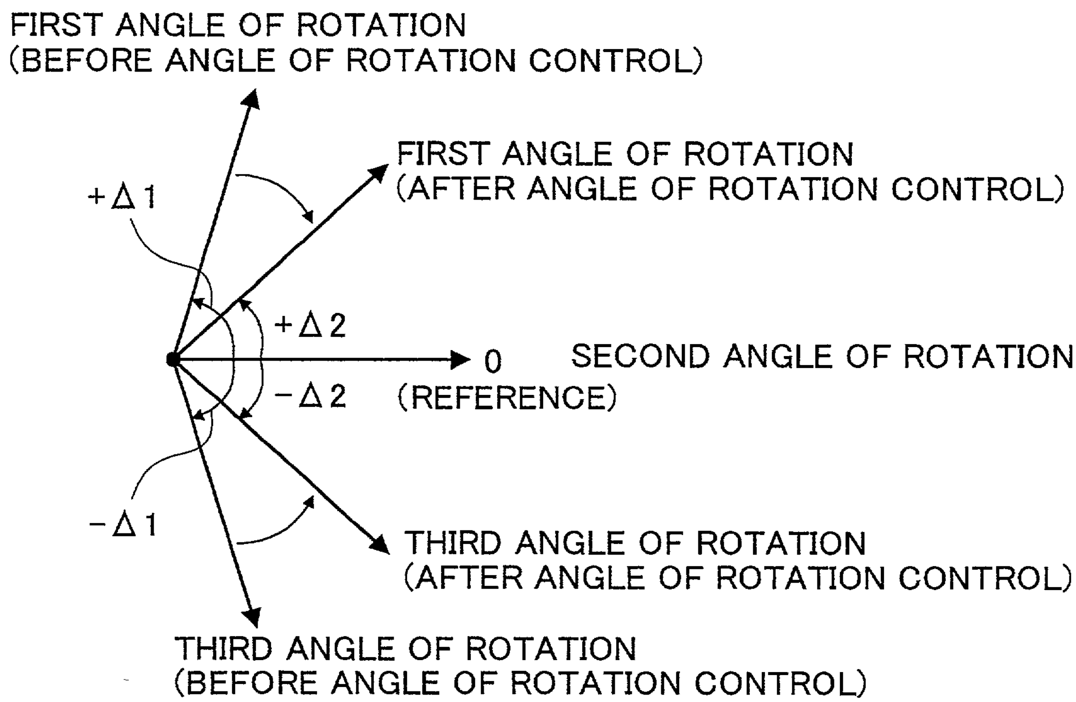
FIRST ANGLE OF ROTATION
(BEFORE ANGLE OF ROTATION CONTROL)
FIRST ANGLE OF ROTATION
(AFTER ANGLE OF ROTATION CONTROL)
+Δ1
+Δ2
0
SECOND ANGLE OF ROTATION
(REFERENCE)
−Δ2
−Δ1
THIRD ANGLE OF ROTATION
(AFTER ANGLE OF ROTATION CONTROL)
THIRD ANGLE OF ROTATION
(BEFORE ANGLE OF ROTATION CONTROL)

FIG.5

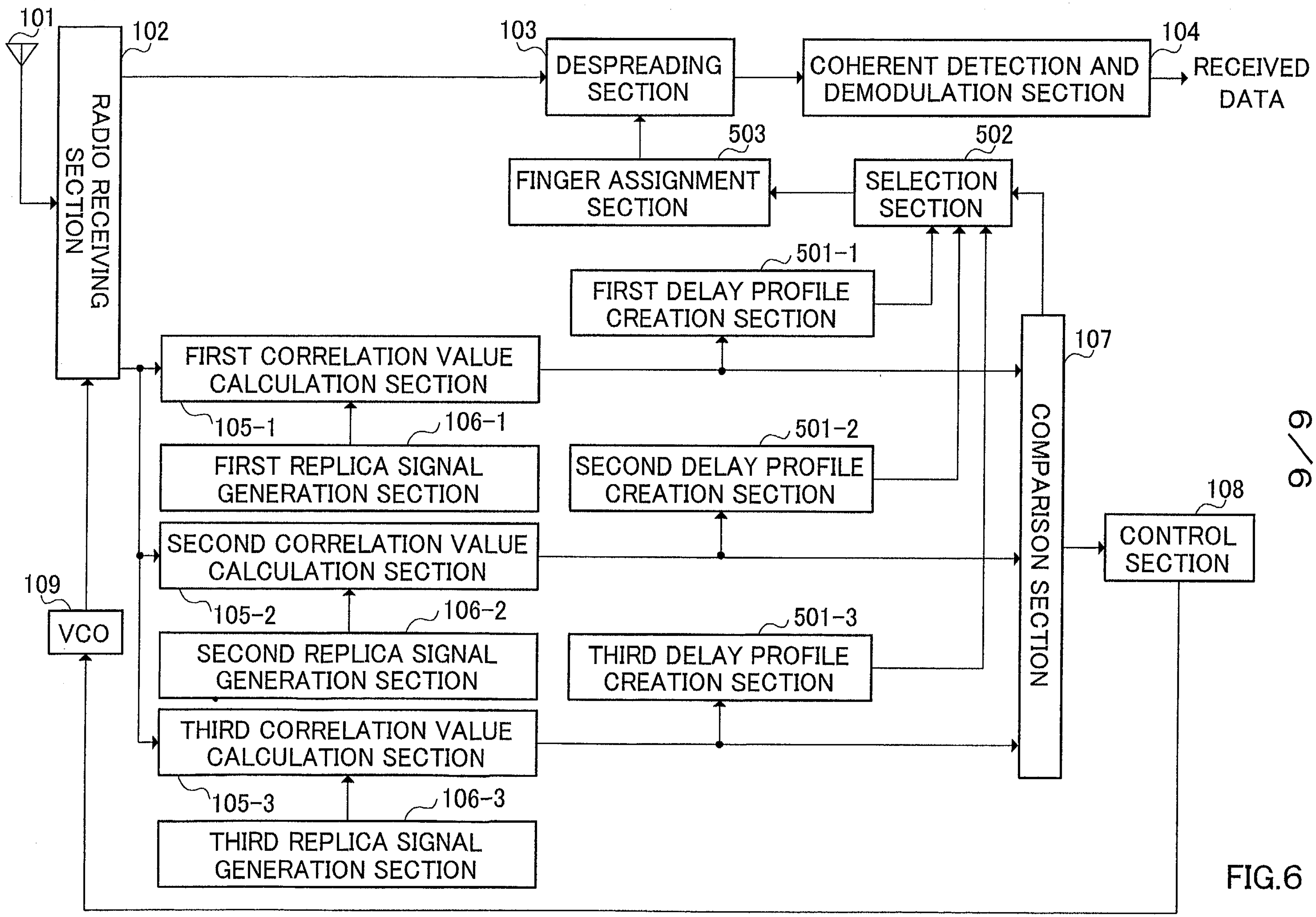
101
102
RADIO RECEIVING SECTION
103
DESPREADING SECTION
COHERENT DETECTION AND DEMODULATION SECTION
104
RECEIVED DATA
503
FINGER ASSIGNMENT SECTION
502
SELECTION SECTION
501-1
FIRST DELAY PROFILE CREATION SECTION
FIRST CORRELATION VALUE CALCULATION SECTION
105-1
106-1
FIRST REPLICA SIGNAL GENERATION SECTION
501-2
SECOND DELAY PROFILE CREATION SECTION
SECOND CORRELATION VALUE CALCULATION SECTION
105-2
106-2
SECOND REPLICA SIGNAL GENERATION SECTION
501-3
THIRD DELAY PROFILE CREATION SECTION
THIRD CORRELATION VALUE CALCULATION SECTION
105-3
106-3
THIRD REPLICA SIGNAL GENERATION SECTION
107
COMPARISON SECTION
108
CONTROL SECTION
109
VCO

FIG.6

PPLICATION FOR UNITED STgATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: CDMA RADIO RECEIVING APPARATUS AND CDMA RADIO RECEIVING METHOD

the specification of which 2 (file no ____________)

(check at least one) 3 [X] is attached hereto
4 [ ] was filed on ____________ as (5) U.S. Application Serial No. ____________
6 [ ] and was amended ____________ (if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.		
7 [x]	was filed as PCT international application	
8	Number **PCT/JP00/08375**	
9	on **November 28, 2000**	
	and was amended under PCT Article(s) 19 and/or 34	
10	on ____________	(if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119 — Priority Claimed

	(Country)	(Number)	(Day/Month/Year Filed)	Yes	No
11a	**JAPAN**	**JP11-340121**	**30/11/1999**	[x]	[ ]
				[ ]	[ ]

[ ] Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

	Application No.	Day/Month/Year Filed	Application No.	Day/Month/Year Filed
11b				

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application	I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application. 13 ____ (U.S. Application Number) ____ (U.S. Filing Date) ____ Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036, TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.

See page 2 for signature lines

other side for instructions for completing this form

INSTRUCTIONS FOR COMPLETION OF THIS FORM

line 1 Insert the same title as is used on the specification and in the assignment.

line 2 Is optional but is provided so that you can use it to identify more readily an application prior to the time that the Patent Office application serial number is assigned. We suggest that the specification, drawings and declaration always bear a file number since it can help to get the papers together in case they become inadvertently separated. In instances where the specification is filed without a signed declaration form (under 37 CFR §1.53) a file number on a later-received separate form will assist us in associating it with the correct case.

line 3 Check this box if the specification, claims and drawing (if any) are attached to this declaration form, e.g., when filing a new patent application.

lines 4-5 Are only used in an instance where the application is already on file and the declaration from is being separately filed, e.g.,when the application was originally filed without a signed declaration or where the Patent Office has required a new declaration because of a deficiency in the original declaration. In such an instance the Patent Office will require that lines 4 and 5 be completed with the filing date and application serial number already assigned.

line 6 Is used in conjunction with line 5 but only when there have been one or more amendments to the specification or claims. Line 6 is also used when the Examiner requires a new declaration because claims inserted by amendment cover subject matter not originally claimed (37 CFR §1.67).

lines 7-10 Are for PCT (Patent Cooperation Treaty) cases and are used only when you are entering the U.S. National phase (Chapter I or II) based upon a previously filed PCT International application designating the U.S.

line 7 Check this box if this is a PCT National Phase application.

line 8 Insert PCT International application number.

line 9 Insert date of filing of PCT International application.

lines 10 Insert the date of all amendments filed in the PCT International application. Such amendments are optional, so this line at times will not be used.

line 11a Is used in the following instances:

(i) If a single priority is being claimed from a foreign application you need to list only the first-filed application; you do not need to list other countries if all applications were filed within one year of the U.S. filing.

(ii) If multiple priorities are being claimed, from a plurality of applications filed in one or more countries, you must list the first filed application for each aspect of the invention. Example: if aspect A of the invention was disclosed in an application filed 11 months earlier in country X and aspect B was disclosed 9 months earlier in an application filed in country Y, then the applications in both countries X and Y must be identified. Only the first application for each aspect of the invention needs to be identified provided all applications on that aspect were filed within one year prior to the U.S. filing.

(iii) If a non-priority application is being filed you must list all applications in all countries where corresponding foreign applications were filed more than one year prior to the U.S. filing. This is so the Examiner can check to see if any of those applications were published or patented early enough to be prior art against the U.S. application.

(iv) If there are more than two applications to be listed we suggest that you type in on this form only "See attached Schedule A" and then list all of the previous applications on an attached sheet.

line 11b Is used to claim priority under 35 USC §119(e) based on a provisional application filed within one year of the filing of the instant application. More than one provisional application may be identified provided neither was filed more than one year earlier.

line 12 This block is used only in instances where there is a previously filed U.S. non-provisional application which was copending at the time the present application was (or is being) filed. that previous application could be a U.S. non-provisional application or the National Phase of a PCT allocation. In such a case the present application may be entitled to the priority of the previous application's U.S. filing date (and consequently the foreign priority thereof) provided the present application is identified as a continuing application (continuation, divisional or continuation-in-part) of the earlier (parent) application. If the foregoing is applicable, please fill in one line for each such prior application.

line 13 Type the inventor's proper legal name in the order specified, e.g., "John B. JONES" or "J. Bob JONES" if the inventor so prefers. It is not acceptable to use only initials such as "J. B. JONES."

line 14 The inventor's "signature" may be his (or her) usual manner of signing but it is preferable that the inventor simply write his (or her) name in his (or her) own cursive handwriting in the same order as on line 14, e.g., given name, middle initial and Family name.

line 15 Insert the actual date of signature.

line 16 Insert simply the city and state or country, e.g., "Paris, France", of the inventor's residence, not citizenship. No street address or postal code is required on this line.

line 17 Insert the inventor's citizenship. The statement of citizenship (or subject of) is a statutory requirement (35 USC §115). Simply the name of the country of citizenship, e.g., "Japan" is sufficient.

line 18 Insert the inventor's mailing address. The purpose of requiring the post office address is to enable the Patent Office to communicate directly with the inventor if desired, such as in the case of death of the U.S. attorney. It should be the address where the inventor customarily receives his (or her) mail and should include the postal code. If applicable it can be the inventor's business address or address at place of employment.

Applicants are reminded that the U.S. Patent and Trademark Office has very strict requirements as to proper execution of an application. The applicant should make sure that he reviews the declaration, prior to signing to make sure the declaration properly identifies the application and all relevant information; and should review the specification and claims (including drawings, if any) before signing the declaration. Failure to do so will require the filing of a supplemental declaration --- 37 CFR §1.67(c)

Any handwritten changes to the specification, claims or drawings must be in ink personally by all of the inventors prior to signing the declaration and the adjacent left margin must be initialed and dated by all of the inventors, e.g., "JBJ 6-9-91".

Please let us know if there are any questions regarding proper completion of this form. Thank you.

An assignment, a separate document requiring separate signature and dating may be enclosed. Please look for it and sign and date it in the same manner as in lines 15 and 16 above.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

13a	Typewritten Full Name of Sole or First Inventor 1-00	**Hideo** (Given Name)	(Middle Name)	**FUJII** (Family Name)
14a	Inventor's Signature	Hideo		Fujii
15a	Date of Signature	June (Month)	8 (Day)	2001 (Year)
16a	Residence	**Yokosuka-shi** (City)	**Kanagawa** (State or Province)	**JAPAN** JPX (Country)
17a	Citizenship	**JAPAN**		
18a	Post Office Address (*Insert complete mailing address, including country*)	**6-2-703, Hikari no Oka, Yokosuka-shi, Kanagawa 239-0847 JAPAN**		
13b	Typewritten Full Name of Sole or Second Inventor 2-00	**Masaki** (Given Name)	(Middle Name)	**HAYASHI** (Family Name)
14b	Inventor's Signature	Masaki Hayashi		
15b	Date of Signature	June (Month)	8 (Day)	2001 (Year)
16b	Residence	**Yokosuka-shi** (City)	**Kanagawa** (State or Province)	**JAPAN** JPX (Country)
17b	Citizenship	**JAPAN**		
18b	Post Office Address (*Insert complete mailing address, including country*)	**6-2-505, Hikari no Oka, Yokosuka-shi, Kanagawa 239-0847 JAPAN**		
13c	Typewritten Full Name of Sole or Third Inventor	Given Name	Middle Name	Family Name
14c	Inventor's Signature			
15c	Date of Signature	Month	Day	Year
16c	Residence	City	State or Province	Country
17c	Citizenship			
18c	Post Office Address (*Insert complete mailing address, including country*)			
13d	Typewritten Full Name of Sole or Fourth Inventor	Given Name	Middle Name	Family Name
14d	Inventor's Signature			
15d	Date of Signature	Month	Day	Year
16d	Residence	City	State or Province	Country
17d	Citizenship			
18d	Post Office Address (*Insert complete mailing address, including country*)			

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.